

Investigation of Sampling Low-Altitude Wind Profiles for Space Vehicle Applications

BJ Barbré
Jacobs ESSSA Group
MSFC Natural Environments
March 2, 2016

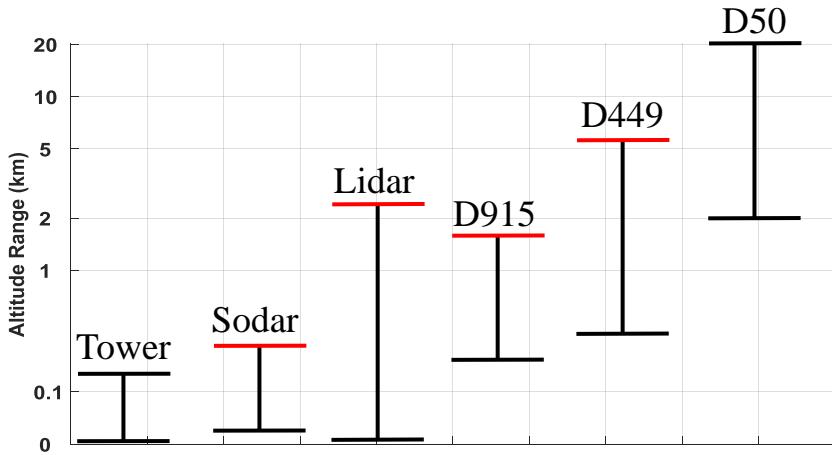
Background

- Eastern Range (ER) and Western Range (WR) 915-MHz Doppler Radar Wind Profilers (D915s) are aging and their performance has been degrading.
- MSFC Natural Environments (NE) is investigating if there exists a better option to supplement the D50 (i.e., replace the D915s with something else).
- Based on known requirements for NASA's Space Launch System and for MSFC NE climatology development, the following is desired:
 - Lowest reliable measurement altitude of at most 300 m.
 - Continuous temporal sampling at least once every 5 minutes.
 - Vertical sampling interval of at most 150 m.
 - Maximum reliable measurement altitude of at least 3 km. *
 - Cost efficient.
 - Others?

Current Status

- Different sources to supplement the D50:

Balloons	<ul style="list-style-type: none">• Miss temporal wind change over short (e.g., sub-hourly) time intervals.• Sample size of archive does not produce a robust climatology.
D915	<ul style="list-style-type: none">• Do newer systems perform better than the current systems?
D449	<ul style="list-style-type: none">• Good max altitude, altitude interval, and time interval.• Min altitude is higher than desired.
Lidar	<ul style="list-style-type: none">• Highly configurable: Could be used to supplement a D449 / D50 combo, or the D50 alone.• Need to examine performance in cloudy conditions and feasibility of continuous operation.
Sodar	<ul style="list-style-type: none">• Could be used for altitudes below the D449.• Need to examine for altitude coverage and data availability.



- Examples of Technology advances
 - High Altitude Lidar for Atmospheric Sensing (HALAS)
 - National Center for Atmospheric Research Modular Profiler Network (<https://www.eol.ucar.edu/node/156>).

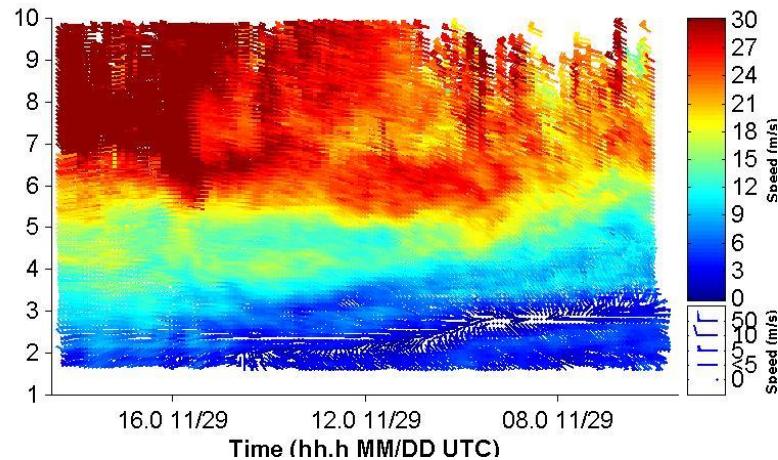
Forward Work

- Soliciting feedback from the Ranges and launch vehicle programs.
 - Understanding requirements.
 - Knowledge of instrumentation and costs.
 - Timeline for replacing the D915s.
- MSFC NE intends to provide an update at the Autumn 2016 NEDOLWG.

Backup

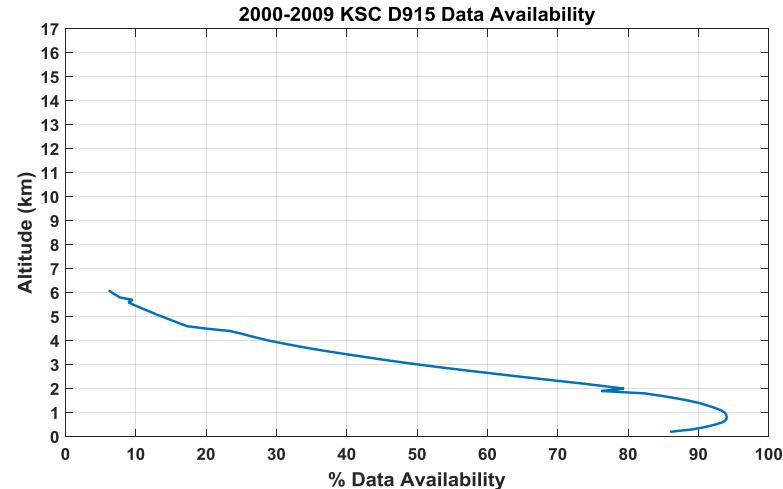
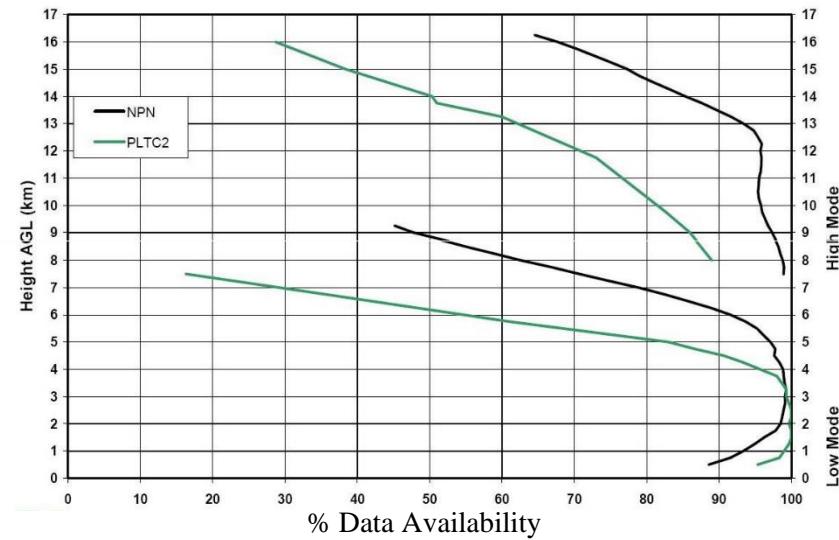
Introduction to the D449

- Traditional systems have an aperture of $\sim 28 \text{ m}^2$.
- Detects signal through Bragg Scattering.
 - Turbulent fluctuations in the atmosphere of scales roughly half the radar's wavelength.
 - Wavelengths: D50, 6 m; D449: 0.7 m, D915: 0.3 m.
- Signal retrieval traits allow for the following versus the D915:
 - Greater penetration through the atmosphere.
 - Similar minimum reporting altitude.
- Plot from heritage D449 at Ft. Huachuca (near Sierra Vista, AZ).
 - Sampling interval of 100 m.
 - 15-min average wind profiles, updated every 5-min.



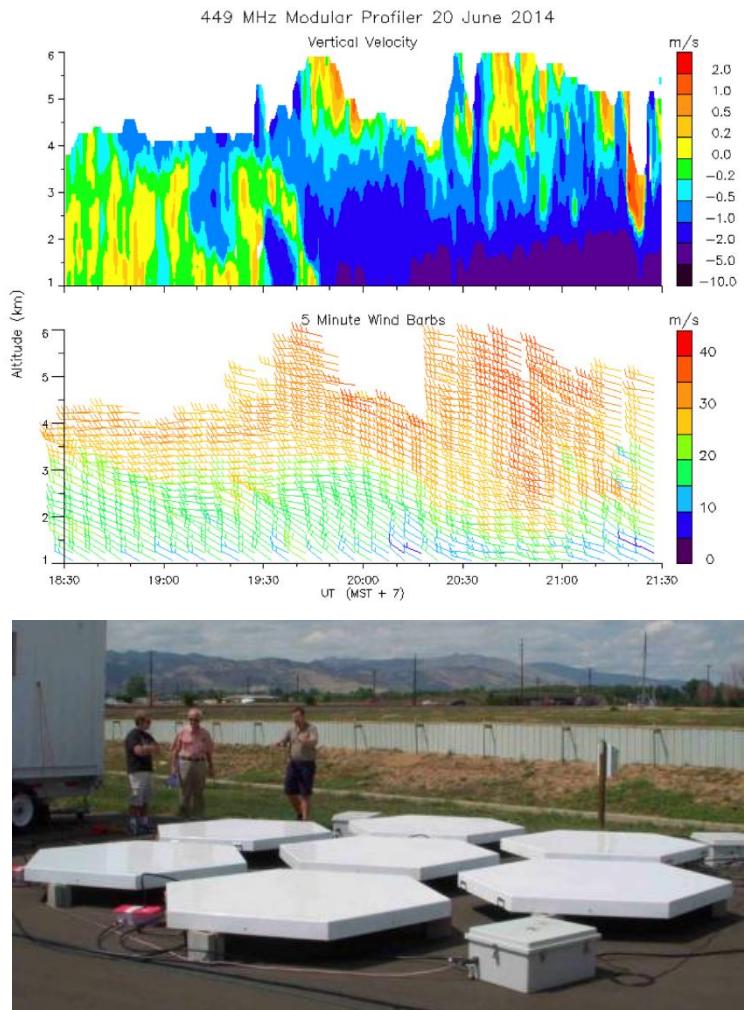
D449 vs D915 Data Availability

- Top plot shows % data availability from:
 - NOAA Profiler Network (NPN), containing 35 D404s and D449s in the Central US.
 - PLTC2, an individual D449 located in Platteville, CO.
 - Period of record 2/1/04 - 4/30/04
- NPN low-mode availability is at least 90% from ~0.5-6.0 km.
 - Overlaps D50 from 2-6 km.
 - Redundant measurement capability.
- Bottom plot shows results from the same analysis using the KSC D915 archive.
 - Same scale.
 - 90% data availability from ~0.5-1.5 km.



The NCAR Modular Profiling Network

- Developers
 - National Centers for Atmospheric Research (NCAR) / Earth Observing Lab (EOL)
 - University of Oklahoma's Atmospheric Radar Research Center (ARRC)
- Modular D449 with multiple module configuration options.
 - Each module has its own transmitter, receiver, and processing unit.
 - Arrangements consist of using one, three, or seven modules. Developers propose to use up to 19 modules.
- Modular Profiling Network (MPN) includes a mini-Lidar for low-level wind data collection.
- Working to improve lowest altitude and height resolution (currently 300 m and 150 m, respectively).



Requirements versus System

	Balloon	D915	D449	Lidar	Sodar	Other?
Minimum Altitude	Yes	Yes	?	Yes	Yes	?
Altitude Interval	Yes	Yes	Yes	Yes	Yes	?
Maximum Altitude	Yes	?	Yes	?	?	?
Temporal Interval	No	Yes	Yes	?	?	?
Qualitative Cost	?	?	?	?	?	?
Other?	?	?	?	?	?	?